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Cross-corrugated packing structure

The present invention relates to a cross-corrugated packing structure. In particular, it relates to a cross-corrugated packing structure for installations for transferring material and/or heat between a gas phase and a liquid phase, and more particularly distillation such as cryogenic distillation.

The invention has a particularly advantageous application in the field of cryogenic distillation, particularly for separating air gases or for separating mixtures containing hydrogen and carbon monoxide.

In this type of application, the cross-corrugated packing structure is the reference as regards organized packings. It consists of a set of modules or "packs", each formed from a stack of surfaces, or strips, obliquely corrugated alternately in one direction and in the other.

The corrugations of each surface, also called fins, consist of parallel channels made from smooth or textured sheets, generally metal, perforated or not. For example, a surface for cross-corrugated packing can be fabricated economically from a standard grade aluminum strip by simple mechanical operations, such as bending and perforation.

In the case of distillation columns, the corrugated surfaces are contained in vertical planes general. The modules are usually turned through 90° about the axis of the column from one pack to the next.

The cross-corrugated structure is imposed today as the only one permitting the construction of columns of

all sizes without reducing the intrinsic efficiency observed at small scale.

By varying the height of the fins, the density of the structure, expressed in m^2/m^3, can be adjusted. In doing so, a contrariwise change is observed in two properties, whose optimization is also desirable, that is, capacity and efficiency. In fact, a dense structure with a high m^2/m^3 value provides a high efficiency packing but one which, by easily flooding, offers low capacity. Conversely, a loose structure permits high throughputs, but with lower efficiency.

By adjusting the density, various types of packing structures can be defined to adapt ideally to the various cases considered, for example:

- high efficiency structures are reserved for small columns, where diameter is not the main parameter,
- conversely, for very large units, and to obtain a maximum throughput in a diameter imposed by construction and/or transport restrictions, priority is assigned to capacity, even if the height may have to be increased.

To reduce the flooding effect that limits the capacity of the cross-corrugated packing structures conventionally used, WO 97/16247 proposes, as surface corrugations, S shaped channels whose generatrices are curved at each end to become vertical at the upper and lower edges of the module. This particular shape, which makes the channels vertically upright at the interfaces between packs, has served to optimize the "efficiency-capacity" curve in the sense that, for the same structure in terms of general channel shape and density, the flooding limits have been extended by about 30%, without substantially affecting efficiency.

However, even if it has marked a considerable advance in the field of cross-corrugated packings, the

latter structure of S shaped channels nevertheless maintains its intrinsic limits, that is, by increasing the channel density, to achieve higher efficiency, the spatial mesh is densified, and capacity is reduced, and, conversely, by enlarging the spatial mesh, capacity is increased but correlatively, the interfacial area and hence the efficiency of the gas-liquid exchanges is decreased.

Thus, the technical problem to be solved by the object of the present invention is to propose a cross-corrugated packing structure for cryogenic distillation installations, comprising a first surface, called primary surface, having a plurality of parallel channels, decisively extending the limits inherent in currently known structures, including that described in WO 97/16247.

According to the present invention, the solution to the technical problem consists in forming the secondary elements separately from the first surface.

The secondary elements may be detachable.

The design of this type of structure with two surfaces, and not a single surface as in the structures of the prior art, results from the applicant's merit in having realized that the limits of the known cross-corrugated packings are due to the fact that the single surface, known as the main surface in the context of the present invention, simultaneously performs two functions, on the one hand, at a "macroscopic" scale, the spatial organization into an infinity of intersecting channels for exchanges between opposing channels, and, on the other, at a "microscopic" scale, mass exchanges between the gas phase and the liquid phase.

On the contrary, the invention dissociates these two functions, which are accordingly separated into a primary wide mesh cross-corrugated structure, necessary and sufficient for throughput and uniformity of the flows, particularly in large columns, and a secondary structure, added on to the interior of the primary structure, specifically improving the gas-liquid exchanges, without attempting a spatial organization.

More precisely, since the density of a cross-corrugated packing varies with 1/h where h is the height of the channels, the invention, for a target density that would be obtained with a height h for a conventional single surface structure, serves to obtain the same final density but with a surface distribution between the primary, cross-corrugated surface, and the secondary surface housed in the channels of the primary surface.

One can thereby conceive of a primary surface with a corrugated structure of height 2h, hence supplying half of the total target surface, and a secondary surface supplying the other half, or more generally, as provided for by the invention, a distribution between (1-x) of primary surface and x of secondary surface ($0 < x < 1$).

The description that follows, with reference to the drawings appended hereto, given as nonlimiting examples, will clarify the invention and show how it can be implemented.

Figure 1 is a perspective view of a first embodiment of a cross-corrugated packing structure of the invention.

Figure 2 is a side view of the structure in Figure 1.

Figure 3a is a perspective view of a secondary packing element of the structure in Figure 1.

Figure 3b is a perspective view of a variant of the packing element in Figure 3a.

Figure 4 is a cross section of a variant of the structure in Figure 1 including the fastening tabs.

Figure 5 is a perspective view of a second embodiment of a cross-corrugated packing structure of the invention.

Figure 6 is a side view of the structure in Figure 5.

Figure 7a is a plan view of a secondary packing element of the structure in Figure 5.

Figure 7b is a perspective view of the secondary packing element in Figure 7a.

Figure 8 is a side view of a variant of the structure in Figure 5 including the fastening tabs.

Figure 1 shows a perspective view of a portion of cross-corrugated packing structure designed for cryogenic distillation installations, particularly for separating gas mixtures.

This structure comprises a first surface 10, or primary surface, having corrugations consisting, in the example in Figure 1, of parallel channels 11 with an equilateral triangle cross section as shown in Figure 2.

The structure in Figure 1 also comprises a second surface 20, or secondary surface, consisting of a plurality of secondary packing elements 21, each

secondary element 21 being arranged inside a channel 11 of the primary surface 10.

As shown in Figure 3a and in the variant in Figure 3b, the secondary packing element 21 has a periodic structure along channel 11 of the primary surface 10.

In general, the secondary elements 21 in Figures 3a and 3b can be made from flat metal strips by cutting, perforation and/or bending distinct from the first surface. More precisely, in the embodiments in Figure 3a and 3b, the secondary elements 21 are obtained from a strip of height 2r sectioned at regular intervals along half of its height, leaving a heel 211, 211'. The sectioned parts are alternately bent rightward and leftward equilaterally to form the fins 212', 212". In the case of Figure 3b, the heel 211' has equidistant perforations 213.

The secondary elements 21 thereby obtained are housed inside the channel 11 in the arrangement shown in Figure 2.

In this embodiment, the elementary mesh of the structure consists of the two sides of the equilateral triangle forming the channel 11. Since each side of the channel participates in two channels, the cross section per channel 11 of primary surface is proportional to $r\sqrt{3}$, where r is the radius of the circle circumscribed in the equilateral triangle in Figure 2. Furthermore, the cross section of the secondary element 21 is proportional to 2r. The cross sectional distribution between primary surface 10 and secondary surface 20 is thus made in a ratio of (1-x) to x with x close to 0.5, here x = 0.464.

In the variant in Figure 3b, the ratio (1-x)/x is lower, but remains about 1.

According to the embodiment in Figure 5, the basic corrugated primary surface 10 is identical to that in Figure 1 with an equilateral triangle elementary channel 11.

By contrast, the elementary element 31 of the secondary surface 30 of the packing structure is cut out from a strip along the plane in Figure 7a, then bent to form the corrugations as shown in Figure 7b, which are then housed in the channel 11.

The cross section of the secondary surface 20 is lower here than in the preceding case. A greater restriction is also introduced in the cross section offered to the gas (in the first example, the secondary surfaces are strictly parallel to the gas flow), and an exchange element is similarly introduced between channels, the gas deflected by the inclined surface forming an obstacle being redirected toward the opposite channel.

As shown in Figures 4 and 8, the secondary elements 21 and 31′ can be snap fastened in the channel 11 by means of tabs 40, 40′ arranged on the secondary elements 21, 31′ and inserted into openings 41 made through the walls of the channel 11.

Obviously, many variants exist for the basic shapes described above with reference to the drawings appended hereto, either by varying the bending pitch and the angles, or by adding additional folds to the secondary structure forming deflectors.

Another family of solutions consists in placing twisted strips forming secondary elements with an endless screw structure.

Irrespective of their shape, the secondary surfaces are hence individual elements to be housed in each channel.

The S shape of the new packings as described in international application No. WO 97/1624, provides an effective closure of the channels at their ends: once the packing module is constructed, the secondary surface elements are imprisoned in the channels, even if not physically attached thereto.

Once the secondary elements are placed in the channels of a packing strip, one strip out of two is turned over and mounted intersecting the first. The strip to be turned over may be temporarily covered by a plane face, the combination turned over on the other corrugated strip and the plane face then slid out by pulling.